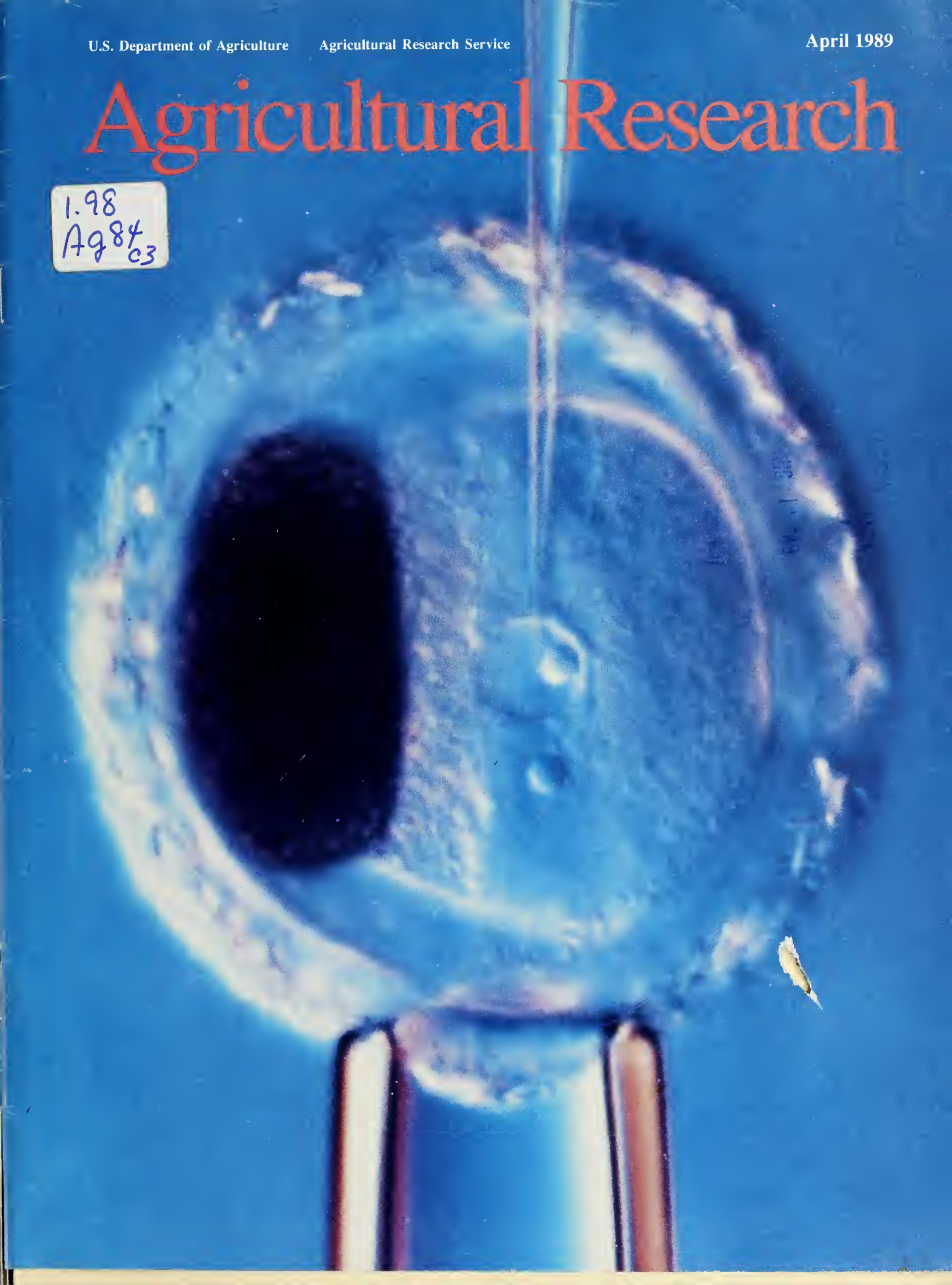
U.S. Department of Agriculture Agricultural Research Service April 1989

Agricultural Research



Potential Danger in Excess Supplements

I often feel frustrated when the public is advised to take supplements of specific nutrients when the metabolism of this nutrient is not yet completely understood by science. There's a popular misconception that if a little of a substance is good, more is better. But as a nutrition scientist, I know that more is not always better; more in fact, can be deadly.

Conversely, elements we know as deadly can actually be essential. Take arsenic, for example. Wasn't it the poison of choice for two nutty old sisters in "Arsenic and Old Lace"? With it, they "did in" several unsuspecting elderly men in the popular 1930's comedy.

Few at the time would have guessed that arsenic would be thought essential—in very trace amounts—in the 1980's. Yet some 40 years after the play reminded us of arsenic's poisonousness, researchers at ARS' Grand Forks Human Nutrition Research Center and in Germany reported several symptoms of arsenic deficiency in various experimental animals.

The symptoms suggest that the element is essential for optimum functioning of animals and, by implication, may be for humans. How it operates in the body and how much is required are questions still waiting for answers.

Thanks to the persistence of German-born physician Klaus Schwarz, an even more potent but less notorious poison, selenium, was shown to be essential in 1957.

It took more than a ton of pork kidneys for Schwarz, who was then at the National Institutes of Health, to isolate slightly more than a milligram of a biologically active factor that was found to contain selenium.

Shortly afterward, Schwarz and others demonstrated that a costly disease of poultry was due to selenium deficiency and could be prevented by adding *tiny* amounts of the element to the feed—one-tenth of one part selenium to one million parts of feed.

More than 20 years and many studies later, the National Research Council suggested a daily intake of between 50 and 200 micrograms (millionths of a gram) as "safe and adequate" for humans. Even the upper limit—200 micrograms—is too small for the naked eye to see.

There's a good reason for caution in establishing a dietary requirement. For many nutrients—and this is especially important for trace elements—scientists have categorized four distinct dietary ranges:

- The *deficient* range provides too little to maintain normal biological function,
- The *physiological* range provides the optimum level for normal function and is continually subject to revision as more is learned about the nutrient,
- The *pharmacological* range improves some biological functions at the expense of others, and
- The *toxicological* range confers no benefits and damages one or more functions, sometimes to the point of death.

Thus, when dealing with nutrient intakes, it's unwise to assume: "If a little bit is good, more must be better."

The width of the physiological range, or window, varies greatly depending on the element. For instance, the safe and adequate range for calcium is about 10,000 times more than that for selenium. The dose increase that moves selenium from its physiological to its toxicological range would be inconsequential for calcium.

It's nearly impossible to get a toxic level of an essential element through food sources, but problems arise when people try to supplement their dietary intake. Furthermore, trace elements compete with one another. An excessive zinc intake, for example, may cause a copper deficiency even though dietary copper is adequate before zinc is added. Too much manganese can compromise a person's iron status, and so on.

Several new elements are candidates for essentiality at very low levels. One of those, boron, made news in late 1987 when the results of the first human study at our lab suggested that the element might help prevent osteoporosis.

The amount of boron used in this and subsequent human studies was 3 milligrams—the weight of three grains of salt. The evidence from 8 years of animal studies and three human studies (see article on page 12) indicates that boron can influence bone metabolism, but it's still not clear whether the effects are always beneficial.

Based on the first human study, however, at least half a dozen companies now have boron supplements on the market—including a boron-steroid body builder! Although boron compounds are far less toxic than arsenic or selenium, adults and infants have been known to die from overdoses.

This is why we strongly suggest that people avoid taking these supplements until more is known about this potential nutrient—especially until a dose is established that is safe over the long term. Meanwhile, it is reassuring that a well-balanced diet that includes fresh fruits and vegetables contains ample boron.

Curtiss D. Hunt
Research Anatomist
Human Nutrition Research Center
Grand Forks, North Dakota

Agricultural Research

A fertilized swine egg photographed at the moment it is microinjected with new genetic material. Vacuum in the large pipette at bottom anchors the cell while a mixture containing the genes is forced through the smaller pipette into one of the egg's pronuclei. Photo courtesy of R.E. Hammer and R.L. Brinster, University of Pennsylvania School of Veterinary Medicine.

Page 10

Page 14

Page 15

Vol. 37, No. 4
April 1989

Editor: Lloyd E. McLaughlin
Associate Editor: Regina A. Wiggen
Photography: Bob Bjork, Anita Daniels, John Kucharski

Agricultural Research is published 10 times per year by the Agricultural Research Service (ARS), U.S. Department of Agriculture, Washington, DC 20250. The Secretary of Agriculture has determined that publication of this periodical is necessary in the transaction of the public business required by law of the Department.

Subscriptions: $11.00 for 1 year (10 issues) in the United States or $13.75 foreign. Prices subject to change and should be verified after May 31, 1989. Send orders to Superintendent of Documents, Government Printing Office, Washington, DC 20402. Request *Agricultural Research,* stock number 701 006 00000 3.

Magazine inquiries or comments should be addressed to: The Editor, Information Staff, Room 316, Bldg. 005, Beltsville Agricultural Research Center-West, Beltsville, MD 20705. Telephone: (301) 344-3280. When writing to request address changes or deletions, please include a recent address label.

Clayton K. Yeutter, Secretary
U.S. Department of Agriculture

Orville G. Bentley, Assistant Secretary
Science and Education

R.D. Plowman, Administrator
Agricultural Research Service

First of a two-part series. . .

Farm Animals of the Future

ARS geneticist Chris Davies performs a cytotoxicity assay on a blood sample which helps to identify animals that have superior resistance to certain diseases. (K-3122-2)

Broilers blooming to market size 40 percent quicker, miniature hens cranking out eggs in double time, a computer "cookbook" of recipes for custom-designed creatures—this could well be the face of animal production in the 21st century.

At least some of the keys to these sorts of scientific miracles are already in the hands of researchers, according to Robert J. Wall, a physiologist with USDA's Agricultural Research Service. Wall works at ARS' Reproduction Laboratory at the Beltsville Agricultural Research Center in Beltsville, Maryland.

"We'll analyze the entire genetic composition of the animal and store that information on computers," says Wall. "Then we'll be able to hook up a machine we already have, called a DNA synthesizer, and recreate the genes we want.

"Simply put, there are only five letters in the genetic alphabet, and only four occur in DNA—A, T, C, and G. These letters stand for the names of a kind of molecule called a nucleotide base. These bases occur in sequences—say ATCCGATCCG. The particular order of the letters and the length of the sequence, that's basically the recipe for a gene."

The chemicals represented by A, T, C, G, and U are no mystery, Wall says: "I have them in bottles in the refrigerator." But that doesn't mean scientists are ready to start building an animal from scratch.

"We can read the sequence of specific genes, although only in the last 10 years have we had the ability to do this with genes from higher organisms," Wall

says. "We know the words, but we don't know the syntax of the sentences. There may be 100 genes involved in eye color. We have to learn not just what they are, but how they work together.

"We've figured out the sequencing on 1,000 genes, but there are probably 50,000 genes in humans or animals. And the ones we know about, we've reached through sort of a back door approach."

This approach is to identify a disease and determine that it's inherited and then to work backwards until researchers find the gene responsible for a disease.

"Right now, without a disease, we don't have any information to work with. We can read a chromosome from start to finish and write down every A, T, C and G, but we don't know what that sequence is *for*. But someday we will—it will be done.

"There's a lot of concern today about life forms that are in danger of becoming extinct. In the future, we'll be capable of recreating an animal that no longer exists, drawing from genetic information."

The American broiler is definitely not in danger of extinction—some 5 billion birds hit the market in 1987. But they'll be doing that even faster in the next century, predicts James W. Deaton, animal scientist at ARS' South Central Poultry Research Laboratory at Mississippi State, Mississippi.

"In 1950, it took 84 days to produce a 4-pound broiler with a feed conversion rate of 3.25 pounds of feed for every pound of meat produced," Deaton notes. "Today it takes 42 days, with a 1.9 feed conversion. In the 21st century, we should be able to produce a 4-pound broiler in 25 days.

"We'll make these gains the same way we reduced production time from 84 days to 42 days, by making the system better: genetics, disease control, nutritional control, and environmental control. But we have to have everything synchronized."

A major part of that synchronization will involve diet, according to Deaton.

"Those birds will be fed a pasteurized liquid with total nutritional control and balance," Deaton says. "We'll liquefy the ingredients, put them in a refrigerated container, and let the chickens drink their dinner from a waterer or nozzle system. This should improve ease of handling and ease of digestion, too."

Vaccinations could become a thing of the past. Instead, producers will grow "birds in a bubble," using a completely closed environment.

"We'll eventually go to a totally controlled environment with filtered air," Deaton predicts. "We're going more and more toward that already. It will be expensive, but no infectious diseases will come into the flock. And look how much more meat you can produce; since the temperature will be closely controlled, the chickens won't have to use any of their feed to stay warm, so you can produce more meat."

Breeder hens are in for a change, too. "Today a breeder hen produces about 140 chicks a year," Deaton says. "In the 21st century, we should be able to double that, primarily through artificial insemination. The turkey industry is already totally AI, and the broiler industry will do that, too.

Animal geneticist Lyman Crittenden and technician Leonard Provencher check chickens maintained in plastic canopy isolators to test for avian leukosis viruses that do not induce tumors. Scientists in the future will manipulate not only the birds, but also the pathogens that threaten them. (K-1722-9)

"Also, we'll probably make a dwarf breeder hen; there are some of these already. That won't have any effect on the size of the chick, but it will save on feed for the hens."

Fine-Tuning Disease Resistance

Scientists in the next century will have fine-tuned the addition of desirable traits in the birds, such as disease resistance, according to Michael D. Ruff, microbiologist at ARS' Protozoan Diseases Laboratory at Beltsville.

"When you select birds for disease resistance, it's hard to get that trait and

still keep the production qualities you want," says Ruff. "Say, for example, you want a bird with the genes 1, 2, 3, and 4. But when you add a bird with one of these genes to your breeding line, it may also have a 6 or 8 gene, which you don't want.

"In the 21st century, instead of having to accept the thousands of genes that are in a bird, some of which we want and some we don't, we'll be able to pull out gene 2 and insert it into another bird's genetic material."

Scientists in the future will manipulate not only the birds, but also the diseases that threaten them, Ruff predicts.

"Take Marek's disease, for which we do vaccinate," he says. "We may alter the causative virus by removing the gene for pathogenicity. Or perhaps we will enhance the bird's immune response to the virus. Or we might be able to change the disease organism so it can't withstand the temperature of the bird's body for very long—just long enough to prompt an immune response, but not long enough to let the disease get a good start."

Gene insertion is also on the minds of swine experts. "But after inserting a foreign gene, we'd have to be able to turn it on and off at will," says Norman C. Steele, an animal scientist at ARS' Non-Ruminant Animal Nutrition Laboratory at Beltsville. "For example, too much growth hormone can expose the animal to very bizarre metabolic disorders."

"We could insert genes that regulate the pig's immune system or give us females that ovulate more. Either of these could lead to more pigs produced per sow. The national average is now 11-12 pigs born per litter, but because of diseases and other problems only an average of 7.7 of these live to weaning size, the same as 30 years ago."

Lawrence A. Johnson, an animal physiologist in ARS' Reproduction Laboratory at Beltsville, says sex preselection will be part of the livestock production picture in the next century.

"I think we're getting close," he said. "Sperm cells carrying the Y chromosome produce males, while sperm carrying the X chromosome produce females. The X-bearing sperm also contains more DNA, which can be measured using a fluorescent dye and a laser.

"We take a sample of semen, treat it with a fluorescent dye, and put it through a cell sorter. The sperm go past a laser beam single-file. As each sperm hits the laser beam, it gives off a different amount of light based on its DNA, so we can tell male and female sperm apart. Based on the light they give off, the sperm are collected in separate containers.

"But there's a drawback—the cell sorter is slow. It can only sort a couple of million sperm a day, and a normal insemination for a cow, for example, requires at least 10 or 15 million sperm. We're trying to identify some sort of sex-specific marker on the surface of the sperm. If we are successful, we could develop a batch procedure for identifying male versus female sperm and thus make the procedure practical."

Lean and Large

The pigs of tomorrow will be bigger, but not fatter," says Norman Steele.

"In the very near future we'll be able to control growth through soma-

Top: ARS animal physiologist Lawrence Johnson checks swine sperm cells on video monitor to evaluate their motility, a procedure that precedes laser X-Y sperm separation. (K-2907-12)

Above: Wood fibers after lignin has been removed by a white rot fungus, *Phellinus pini*. Magnified about 180 times. SEM courtesy Robert A. Blanchette, University of Minnesota. (89BW0533)

totropin," Steele says. "That's a natural growth hormone with tremendous potential to alter not only weight and rate of gain, but body composition. With somatotropin, you can increase the yield of muscle tissue 20 percent and simultaneously reduce the amount of body fat up to 70 percent.

"But it requires a daily dose for about 30 days in the early stages of growth, and it must be administered as an implant. The barrier to using somatotropin is the lack of a feasible delivery system."

Another group of chemicals, called beta-adrenegic agonists, has a major impact on reducing fat on the animal's body and works well in oral doses but leaves the animal in a hyperactive state, Steele says.

"What will happen, in all likelihood, is that drugs will be developed that have no unwanted side effects but will still alter the fat-to-lean ratio."

"Currently, we slaughter pigs at 220 to 240 pounds. The carcass is about 70 percent of the pig's live weight. Of that, the fat-to-lean ratio is now 2-to-1. A ratio of 1-to-1 is easily within our grasp."

The ability to control fat levels will change the market weight of hogs, Steele predicts.

"We slaughter them when we do, mainly because beyond that weight, they become too fat. But if we can control the amount of fat, there's no reason to stop at 240 pounds. We could go to 300 pounds. The key is body composition."

Steers in the future may find themselves contentedly chomping down all sorts of materials that would hardly qualify as quality forage today, according to Robert R. Oltjen. Oltjen is associate deputy administrator for Animal, Human Nutrition, and Postharvest Sciences on ARS' National Program Staff.

"I think in the 21st century, we'll be able to economically unlock the energy in lignin, the binder for fibers in wood," says Oltjen. "And through genetic engineering, we'll be able to come up with a microbe that can chew it up. If that happens—if cattle have lignin-digesting microbes in their stomachs—we can feed them all kinds of woody products if we want to.

"In the future, we'll tailor the breeds of cattle to the climate and feed production ability of a particular area."

Robert R. Oltjen, Agricultural Research Service, Beltsville, Maryland

"We know there are rumen microorganisms that can partially degrade lignin, although not very effectively. Termites, however, are good at it; maybe we can take a gene from them. We could take a microbe that normally lives in the cow's rumen and insert the gene we need."

On a more typical diet, not necessarily one that includes trees or industrial byproducts, "The speed to market size will change a lot," predicts Oltjen. "We'll see cattle grow 50 percent faster. That's because we'll know more about their nutritive requirements and will feed them precisely to those requirements to more fully use their genetic ability for meat production."

Cloning of cattle is certain to be part of the 21st-century scene, says Oltjen, and so will shipping whole "herds" of cattle into and out of the country in the form of frozen fertilized embryos.

Here at home, "I don't think we'll have as many breeds," Oltjen says. "Right now we have 60 breeds of beef cattle in this country. In the future, we'll tailor the breeds of cattle to the climate and feed production ability of a particular area."

Larry V. Cundiff also sees more matching of cattle breeds to environment in the future. Cundiff is a geneticist at the Genetics and Breeding Research unit at ARS' Roman L. Hruska U.S. Meat Animal Research Center at Clay Center, Nebraska.

"We're likely to see new breeds, based on crosses of four or more breeds, selected genetically to match the climate," says Cundiff. "We're conducting experiments now to see how vigorous these crosses are. Our preliminary results are very encouraging."

Cundiff anticipates increased use of "terminal sires," big animals selected strictly for size and lean meat production to father calves headed straight for slaughter.

"These are used to produce calves with more lean than the mother cows have," explains Cundiff. "In a cow herd, low fat is not necessarily such a good thing.

"About 40 percent of the cows could be mated to animals of their own breed

Considering all costs, cows producing twins increase the efficiency of beef production by 20 to 30 percent. (K-1225-11)

to produce replacement heifers. The other 60 percent could be mated to these terminal sires."

Cundiff also expects an increase in twinning of calves, but notes that the gains that have been made there are based on traditional genetic selection, albeit with surprising success.

"We have a project here where we've selected intensely for twinning, using daughters of cows with outstanding twinning capabilities," he says. "And some of the semen used was from bulls with unusual twinning capabilities in their daughters.

"We've had 13 percent twins in our fall calves and 8 or 9 percent in our spring calves, while the norm is only 1 to 2 percent.

"We went into this with the idea of finding out if you could select for twinning, and we've been surprised. We thought it was a lowly heritable characteristic, but now we're not sure."—By **Sandy Miller Hays**, ARS.

[All of the locations mentioned below are USDA-ARS.] Robert J. Wall is at the Reproduction Laboratory, Beltsville, MD (301) 344-2362. James W. Deaton is at the South Central Poultry Research Laboratory, Mississippi State, MS (601) 323-1964. Michael D. Ruff is at the Protozoan Diseases Laboratory, Beltsville, MD (301) 344-2300. Norman C. Steele is at the Non-Ruminant Animal Nutrition Laboratory, Beltsville, MD (301) 344-2359. Lawrence A. Johnson is at the Reproduction Laboratory, Beltsville, MD (301) 344-2809. Robert R. Oltjen is on the ARS National Program Staff, Beltsville, MD (301) 344-4050. Larry V. Cundiff is at the U.S. Meat Animal Research Center, Clay Center, NE (402) 762-3241. ✦

Waste From Power Plants Conditions Soil

Coal-burning plants that generate electricity must remove acid-forming oxides of sulfur and nitrogen from smokestack gases. If released into the air, these gases can contribute to the formation of acid rain, says a U.S. Department of Agriculture scientist.

According to soil scientist William L. Stout, the most promising removal system proposed and tested so far is a process known as atmospheric fluidized bed combustion. Byproducts from this pollution-controlling method of burning coal are environmentally safe to use as a soil conditioner for reclaimed strip mines and for farms that grow several forage and food crops.

This finding is according to a 10-year study by USDA's Agricultural Research Service in cooperation with state experiment stations in Alabama, Virginia, and West Virginia.

"We found no excessive buildup of harmful substances in soil or plants."

William L. Stout, Agricultural Research Service, University Park, Pennsylvania

In this system, crushed coal and finely ground limestone are suspended or fluidized by jets of air and burned at a controlled rate and temperature. Sulfur from the coal reacts with calcium in the limestone to form gypsum, calcium oxide, and some oxides of metals.

The whitish, granular residue contains essential plant nutrients such as sulfur, calcium, magnesium, potassium, phosphorus, iron, molybdenum, boron, copper, and zinc, as well as some toxic heavy metals such as cadmium.

"But crop plants are far less likely to take up heavy metals from fluidized bed residues than from sewage sludge containing them," Stout says. That was confirmed, he adds, in tests done on reclaimed surface mines, orchards, food crops, and pastures.

"We found no excessive buildup of harmful substances in soil or plants," he says. "Cows and sheep did not get toxic quantities from forage. Neither did pigs fed corn, wheat, soybeans, fruit, and vegetables."

Fluidized bed combustion produces about 2,000 tons of residue a day at a 1,000-megawatt power plant—enough for a typical application of residue on 500 acres, according to Stout. All farm uses of the residue must be approved by the appropriate regulatory agencies, he cautions.

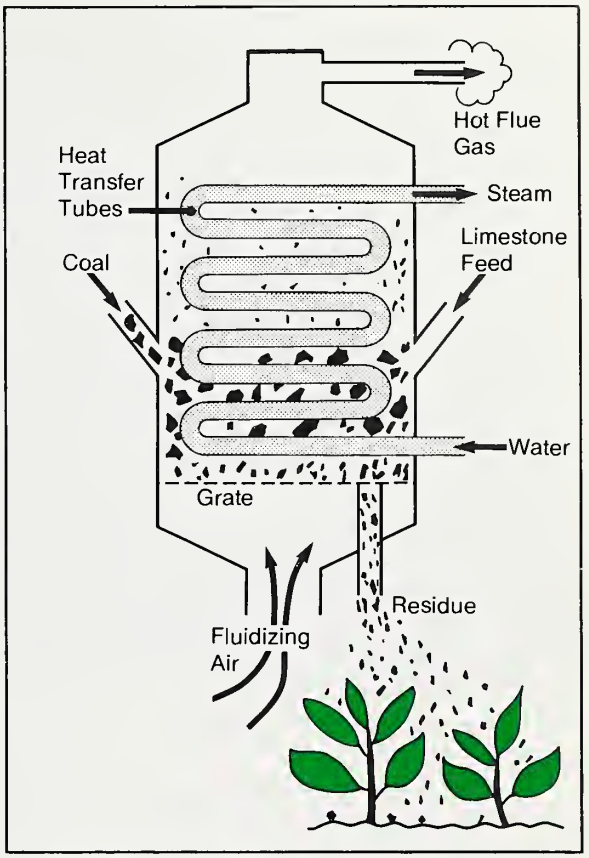
Stout says that the tests show that the residue is best used as a liming agent to lower soil acidity. Its gypsum content gives the residue an advantage over lime: It unites near-microscopic particles of clay to form granules. The spaces between the granules give roots better access to water and fertilizer.

The residue could also be used in roadbeds and as an aggregate in cement and building blocks.

Chemist James L. Hern, formerly with ARS at its Appalachian Soil and Water Conservation Research Laboratory in Beckley, West Virginia, notes that the residue is highly caustic and can severely injure unprotected skin, lungs, and eyes. When handling the substance, people must observe the federal safety guidelines.

According to ARS' Carl Carlson (retired), fluidized bed combustion may also promise an efficient way to dispose of trash in the future. "Many municipalities are already hard-pressed for landfill sites," he says. "Technology gained from the present studies could be used to develop electricity-generating plants that burn garbage without polluting the air. This might put an end to ocean dumping of wastes."

The researchers published recommendations for the safe application of the residue in a manual for power plant managers, consultants, and government agencies in August 1988, says one of its co-authors, soil scientist Ronald F. Korcak of the ARS Fruit Laboratory, Beltsville, Maryland.



Ground limestone in fluidized bed combustion chamber removes sulfur and other potential contaminants from flue gases.

The studies were supported by the U.S. Department of Energy and the Tennessee Valley Authority National Fertilizer Development Center.—By **Vince Mazzola,** ARS.

William L. Stout is in the USDA-ARS Regional Pasture Research Laboratory, Curtin Rd., University Park, PA 16802 (814) 863-0947. Ronald F. Korcak is in the USDA-ARS Fruit Laboratory, Bldg. 004, Beltsville Agricultural Research Center, Beltsville, MD 20705 (301) 344-4650. ✦

The Manual for Applying Fluidized Bed Combustion Residue to Agricultural Lands (ARS-74) may be purchased from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, (703) 487-4600. Cost is $13.95 each plus $3.00 handling.

Vernonia, New Industrial Oil Crop

Does the pine tar smell of wet paint make you ill? It doesn't have to...smell, that is.

The characteristic odor of fresh paint is caused by the volatiles in it—molecules that readily evaporate into the air in large amounts, which makes them easy to smell.

These smelly organic solvents have become increasingly recognized as a factor in air pollution. New restrictions on their use have been passed in California, New York, and New Jersey, and other states are likely to follow.

But a new potential industrial oilseed crop *Vernonia galamensis* is the source of a diluent that could substantially reduce such air pollution, at least in oil-based paints, according to Agricultural Research Service botanist Robert E. Perdue, Jr. He has been actively researching the crop since 1984, although his interest in it dates back to the early 1960's, when he first collected some vernonia seed in Ethiopia.

Perdue works in ARS' Systematic Botany, Mycology, and Nematology Laboratory at the Beltsville Agricultural Research Center in Beltsville, Maryland.

The low viscosity of vernonia seed oil will permit it to be used as a solvent in paint, one which because of its unique chemistry will become part of the dry paint rather than evaporate into the air.

"Besides its potential for use in paint, vernonia oil has a lot of other industrial possibilities," Perdue says. "It could eventually be a replacement for petroleum as a source of the raw materials for components in the manufacture of plastics."

The plant, a native of Eastern and Central Africa, is a relative of the thistle. It is thornless, with lavender flowers that set 1-inch clumps of brown seeds.

Commercial probability for raising vernonia rests in these seeds. "They are an incredible source of a naturally epoxidized oil," Perdue says.

Because the crop grows well in tropical and subtropical semi-arid environments with as little as 8 inches of rainfall, vernonia may be a welcome new crop in African countries such as Zimbabwe and Kenya. Agronomists in both nations are cooperating with Perdue in projects to discover the best ways to grow a crop that has never been cultivated before.

Agronomists in Zimbabwe doubled the yield from 1.2 metric tons per hectare in 1986 to about 2.5 in 1987 through improved management. (The 1987 yield is equivalent to 2,230 pounds

At the Chiredzi Research Station in Zimbabwe, Africa, ARS botanist Robert Perdue (left) and agronomist C.T. Nyati of the Ministry of Lands, Agriculture, and Rural Resettlement, inspect a field of *Vernonia galemensis* Its seeds (left) are a source of naturally epoxidized oil, which coating experts believe can be used as a non-air-polluting solvent in the manufacture of oil-based paints. (seeds K-3137-1, flower K-3137-2)

per acre.) They expect they can increase that by breeding better varieties, Perdue says.

"This seems reasonable, considering that when soybeans were first grown in the United States in the 1920's, the yield was 660 pounds per acre and now the average yield is 2,040 pounds per acre and increasing," he says.

Researchers there have already discovered that the plants benefit from being topped—cut off at about 6 inches above the ground—to produce many branches that tend to flower and set seed at the same time, which enhances more even ripening. If they are planted too early, the plants can get as tall as 9 feet before flowering.

"One great thing about the crop is the staying power of the seeds," Perdue says. "They'll stay on the plants for 30 days or more after ripening, so a grower can wait until most of the seeds are ripe before harvesting, even if the flowers bloom at intervals.

At the moment, vernonia has limited possibilities as a crop for the continental United States. The plant doesn't flower until the days are shorter—a trait typical of most tropical plants. And when days are short enough to cause vernonia to flower, they are followed by frosts too soon to allow seeds to form.

"But recently, a variety that flowers 6 weeks earlier than any previously found has been collected in Nigeria, about 11 degrees north of the equator," Perdue says.

"What we need to do now is search the limits of vernonia's range, about 20 degrees north and south of the equator. I'll bet we find one that flowers early enough for it to set seed well in the United States," Perdue says. "Then it will make a great late summer/early fall crop for the Southwest."

Potential demand for vernonia oil just as a diluent for alkyd-resin paints, the kind of oil-based paint used on buildings, has been estimated at 40 million gallons, based on the use of 1 pint of vernonia oil per gallon of paint, according to John C. Graham, director of the Coatings Research Institute at Eastern Michigan University.

"Formulating alkyd-resin paint with vernonia oil could reduce emissions involved in photochemical pollution by as much as 160 million pounds per year," Graham says.

At 891 pounds per acre—the oil yield in the 1987 Zimbabwe tests—about 365,000 acres of vernonia would be required just to meet U.S. needs in the manufacture of alkyd-resin paint. "This figure doesn't include paint production in other industrial countries nor the potential demand from other uses of vernonia oil," he says.—By **Kim Kaplan,** ARS.

Robert E. Perdue, Jr., is in the USDA-ARS Systematic Botany, Mycology, and Nematology Laboratory, Bldg. 265, BARC-East, Beltsville, MD 20705 (301)344-4690. ✦

The Making of an Essential Element?

There's another good reason for eating plenty of fresh fruits and vegetables. Besides their high fiber content, they also provide plenty of boron. And studies at the Grand Forks Human Nutrition Research Center are turning up more convincing evidence that this element should be considered essential for people and animals, not just plants.

Recent findings suggest that boron may be involved in more than building and preserving healthy bones. It could also affect how the body handles copper—a known essential element thought to play a leading role in maintaining a healthy heart. But researchers were frankly surprised when they turned up evidence that boron may also influence brain function.

During a 4-month study at the center, psychologist James G. Penland found substantial differences in brain wave patterns when 15 healthy older men and women ate a low-boron diet, containing only 0.23 milligram (mg) per day, compared with when they took a daily supplement containing 3 mg of boron.

The researchers estimate that a person eating a well-balanced diet with plenty of fresh fruits and vegetables, nuts, and legumes would consume 3 to 5 mg of boron per day.

According to Penland, "differences in brain wave patterns between the two intake levels were very striking and quite systematic. This is the first study to show that boron depletion alters the function of an organ system."

Previous studies indicated that ample boron can help animals or people compensate for a deficit in certain nutrients or hormones, but they hadn't demonstrated a direct physiological consequence of low boron.

Penland used the electroencephalograph (EEG) to measure brain activity of the volunteers in three separate sessions during the 9 weeks of low-boron intake and again during the 7 weeks of boron supplementation.

While the volunteers were awake but relaxed, he measured both the strength and coherence of four different brain wave frequencies at eight locations on the skull.

According to Penland, it's like taking a complex symphony (brain activity) and breaking it down into pure tones (component frequencies). He takes this brain wave data, determines the strength of each frequency, and calculates how it relates to other frequencies across the head. "That gives you a picture of coherence—whether the tones are synchronized, like an orchestra being conducted, or dissonant, like an orchestra warming up."

Researchers were frankly surprised when they turned up evidence that boron may also influence brain function.

Normally, when a person is awake and alert, no particular frequency dominates, he explains. However, during a relaxed state with the eyes closed, such as meditation, there is more alpha activity; delta and theta frequencies predominate during sleep.

One dramatic effect of the low-boron intake was to decrease alpha activity in proportion to total activity and to increase delta activity. The differences "suggest that the volunteers were less alert when their boron intake was low. But brain activity was more coherent among some regions and less coherent among others, which can be interpreted as good or bad depending on the task at hand."

Despite the EEG readings, two of the volunteers contacted by *Agricultural Research* didn't notice any difference in how they felt throughout the study. The two, who ate "only and all of the food they gave us" for 4 months, say they most enjoyed having breakfast at the center each morning with the 13 other volunteers.

After breakfast, each of the volunteers carried home coolers containing their prepared meals for the rest of the day or the weekend. "It was interesting to find I could live on that diet and restrict myself," says one of the menu that repeated every third day. The other thought the menu provided a good variety, noting that "a person normally repeats what they eat whether they're in a study or not."

Another New Boron Finding

While Penland measured the volunteers' EEG's, Forrest H. Nielsen and colleagues collected frequent blood and urine samples and ran numerous biochemical analyses.

"The findings," says Nielsen, "indicate that dietary boron not only affects calcium metabolism but also affects metabolism of copper. Changes in indicators of both calcium and copper status caused by the low-boron intake can be construed as detrimental."

For instance, blood levels of copper dropped during the low-boron period as did blood levels or red-blood cell levels of two copper-containing enzymes—both sensitive indicators of a person's copper status. Nielsen says that biochemically he doesn't know how boron is affecting copper metabolism, but "any decline in copper status is probably undesirable."

This study, like the first human study on boron (see Agricultural Research, Nov.-Dec. 1987), indicates that an adequate intake of boron results in more available calcium and vitamin D—both important for maintaining healthy bones and preventing osteoporosis.

When the volunteers were receiving the boron supplement, they had more of the active form of calcium in their blood and more of a precursor to the active form of vitamin D. When they weren't getting the supplement, they had higher levels of a hormone, calcitonin, that helps maintain a constant blood calcium level and of a protein, osteocalcin, that indicates bone breakdown.

However, the estrogen and testosterone levels of the 10 women in the study did not increase as dramatically during the supplemental period as they did in the earlier study.

Nor did the boron supplement reduce the loss of calcium and other minerals. Nielsen says the design of the second study—with a low magnesium intake and a shorter period of boron depletion—could explain the differing results. Also,

six of the women were either on estrogen therapy or premenopausal.

The researchers are currently analyzing the data from a third human study—one that was 6 months long and done under more controlled conditions.

Interesting but Elusive

"Chemically speaking, boron is an interesting element," says Terrence Shuler, a chemist who works closely with Nielsen. It behaves both as a metal and a nonmetal. Like zinc, magnesium, and other metal elements, boron hooks up with many biological compounds. It also behaves like the nonmetal carbon—the backbone of all biological compounds. Like carbon, "boron forms rings and cages," he says.

After 8 years of studies with rats, chicken, and people of both sexes, the Grand Forks researchers are convinced that boron can cause physiological responses. Sorting out those responses will take years of research. The picture is "really complicated," says Shuler. "There are so many things going on, it's hard to see which organs are affected."

And Nielsen says that their test animals may or may not show a response to boron, depending on their intakes of several other nutrients. So far, these include vitamin D_3; the amino acid methionine; and the essential elements potassium, magnesium, calcium, and manganese. The list is expected to get longer as studies continue.

In short, the element seems to cause physiological changes some of the time but not all of the time. Its effects are elusive. They show up, for instance, when chickens get too little vitamin D or women stop producing enough estrogen to maintain bone mineral content. Based on the animal experiments, says Nielsen, "varying the intake of boron seems to change the ability of about a half dozen hormones—the ones that are involved in calcium metabolism—to carry out their function in the body."

If future research confirms that a person's boron intake can alter brain wave patterns, the element could become a serious candidate for essentiality in the nutrition community.

A major criterion in establishing the essentiality of a nutrient is that its deficiency impairs a biological function from optimal to suboptimal, says anatomist Curtiss D. Hunt, who with Nielsen found the first evidence of a physiological role for boron 8 years ago.

Hunt, who is keeping score, says boron meets most of the criteria for essentiality: It is light in weight and bonds to biochemicals in a way that is suitable for biological function. It is also found everywhere in nature—on earth and in seawater, is present in "significant quantities" in animals, and is relatively nontoxic. Hunt recently found that the chicken has a built-in mechanism for maintaining blood concentrations of boron within a specific range—an important factor in determining essentiality.

"So far," says Hunt, "no study has shown that boron is unequivocally essential for either humans or animals. But there is more than a 50 percent chance that it is." Nielsen is more emphatic: The evidence to date "strongly suggests that boron is an essential nutrient with an important and apparently unrecognized role in calcium metabolism . . . and thus may be a key to preventing osteoporosis."—By **Judy McBride,** ARS.

ARS research psychologist James Penland applies electrode gel to the scalp of volunteer Jayce Kenner as she is prepared for her weekly electroencephalogram (EEG). Kenner's brain activity is recorded along with behavioral, cognitive, mood, and personality variables during a boron nutritional study. (0885X929-18A)

James G. Penland, Forrest H. Nielsen, Terrence R. Shuler, and Curtiss D. Hunt are at the USDA-ARS Grand Forks Human Nutrition Research Center, P.O. Box 7166, University Station, Grand Forks, ND 58202 (701) 795-8456. ✦

Stethoconus, "Dirty Harry" of the Azaleas

From my lofty vantage point, I watched the unsuspecting mark sitting there, quietly eating. Two attackers quickly and boldly sidled up from either side. Each gave the victim a lethal injection. How quickly death came; before my eyes, the victim lay still.

A drug-related street crime? No, I was watching this astonishing event under the microscope of entomologist John W. Neal in the Agricultural Research Service Florist and Nursery Crops Laboratory in Beltsville, Maryland.

The victim was an azalea lace bug, *Stephanitis pyrioides,* being attacked by its only known and recently discovered predator, *Stethoconus japonicus.*

As I watched, mesmerized, the brightly marked insects set about their task. After delivering the paralyzing lethal injections, still holding onto the lace bug with their front legs, they withdrew all its body fluids and dissolved tissue through their stylets (mouthparts), leaving the lace bug an externally intact but completely drained shell.

Meal finished, the *Stethoconus* shook a couple of their six legs, withdrew their stylets, and calmly walked across the azalea leaf that had served as their tablecloth in search of another lace bug.

"We discovered the predator in 1985 on a U.S.-grown potted azalea in Beltsville while studying the field biology of the lace bug," says Neal. "It arrived on its own in the middle of one of our studies. This was unusual, as the *Stethoconus* is a native of Japan. Until now, there has been no known effective predator or parasite of any lace bug species in the United States."

Inadvertently introduced from Japan to New Jersey after the turn of the century, the azalea lace bug quickly spread south to Florida, west to Missouri, and even to Hawaii. It is the most serious pest of evergreen and hybrid azaleas and is the second most damaging pest of other flowering shrubs.

Sucking the cell content from the underside of azalea leaves, the lace bug makes white, unsightly spots on these popular spring-flowering shrubs. These spots reduce plant vigor and subsequent blooms.

Stethoconus japonicus **devours an azalea lace bug. (89BW0120)**

Both insects deposit their eggs on azaleas. Lace bug eggs, laid next to the leaf midrib, hatch in late April or early May. In the strange balance of nature, *Stethoconus* eggs (overwintering in the plant's stems) hatch in June, just when the second generation of lace bugs appears. If eggs of both insects hatched simultaneously, the predator would soon exhaust its food supply.

Adult females can consume 5 or 6 lace bugs each day; the slightly smaller males, only about 2-1/2. The female must have more nourishment since she lays 9 to 15 eggs each day.

Both the *Stethoconus* and the lace bug are tiny insects, only a little larger than a fruit fly. To the naked eye, they look very similar. However, under the microscope, their features are strikingly different.

The lace bug is aptly named because its sculptured body surface looks as though it's covered with lace.

Huge eyes, a thorax topped with a small cone, and a long, needlelike mouth characterize the predator. The mouth consists of two stylets, one for injecting lethal enzymes and the other for withdrawing fluids from victims. Another distinguishing feature is the deeply cleft claws that may allow the predator to hang onto its prey.

"This peculiar-shaped claw was one thing that helped us correctly identify the predator," says Thomas J. Henry, re-

search entomologist with the ARS Systematic Entomology Laboratory.

Henry, who works at the U.S. National Museum of Natural History in Washington's Smithsonian Institution, says that *Stethoconus* was originally misclassified. Henry corrected the error in 1986.

This is the first western hemisphere record of the genus *Stethoconus*, which contains eight Old World species.

Neal says the predator has since been sighted in three other locations in Maryland and probably coexists with the azalea lace bug population.

Michael Schwartz, entomologist with the American Museum of Natural History in Manhattan, found the predator near azaleas in his front yard in July 1987. Schwartz lives in New York's Rockland County, in the lower Hudson Valley. To date, this is the only other sighting outside Maryland.

"Lace bugs had almost destroyed my azaleas," says Schwartz. "Their survival and return to bloom last spring could be due to the hearty appetite of *Stethoconus*."

Although insecticides can easily control the lace bug, Neal says you don't usually notice the pest until substantial damage occurs.

Stethoconus may prove important in controlling lace bug populations, but Neal does not foresee commercial rearing. "But this newly detected predator may eventually disperse over much of the range of its host anyway," he says.—By **Doris Sanchez,** ARS.

John W. Neal, Jr., is at the USDA-ARS Florist and Nursery Crops Laboratory, BARC-West, Beltsville, MD 20705 (301) 344-4559. Thomas J. Henry is at the USDA-ARS Systematic Entomology Laboratory, National Museum of Natural History, Washington, DC 20560 (202) 382-1780. ✦

Lowered Cholesterol in Lab Test

Rice bran might be a powerful cholesterol fighter, if results of a study with cholesterol-fed hamsters prove true for humans.

Results from two laboratory experiments with these animals suggest that rice bran compares favorably with oat bran in lowering blood cholesterol levels.

Bran is the external brown layer that's scrubbed off in milling, leaving the familiar white grains. Right now, bran is available in brown rice, flatbread-style rice cakes, various snack foods, and a topping made of light, sweet-tasting bran flakes.

Scientists Talwinder S. Kahlon, Faye I. Chow, Mei-Chen M. Chiu, and Antoinette A. Betschart in ARS' Food Quality unit, Albany, California, conducted the research.

Kahlon said that young hamsters fed rice bran, plus a high dose of pure cholesterol, with their standard feed had cholesterol levels similar to counterparts who ate the same basic feed plus cholesterol and oat bran.

Although we need cholesterol to keep cell walls healthy and to perform other important jobs in our bodies, Americans who get too much of it risk heart disease.

Further ARS studies with hamsters and a university study with human volunteers are planned. Those experiments may answer key questions: Does rice bran have the same cholesterol-related effects in humans as it did in the cholesterol-fed hamsters? If so, how much bran would someone have to eat every day to see these effects? How is the ratio of "good" (HDL) to "bad" (LDL) cholesterol affected and which component of the bran is responsible for these effects?

In the United States, rice bran has been used primarily as an ingredient in animal feed. However, work by Robin M. Saunders, Robert N. Sayre, and other members of the Food Quality team led to new interest in bran as a high-fiber ingredient in foods for humans.

The team developed a simple process for stopping the natural deterioration of bran's oil into inedible byproducts—a type of rancidity.

Basically, bran that has been taken off the rice kernels is run through an extruder—a standard piece of food-processing equipment. Heat created in the extruder destroys powerful enzymes that would otherwise start oil's deterioration. Stabilized rice bran that results can be used "as is," or the oil can be taken out, leaving fat-free rice bran.

This stabilization process is expected to prove a boon to Third World countries where rice is a staple: The technique makes it practical and economical to extract rice oil for refining into salad or cooking oil.—By **Marcia Wood,** ARS.

All scientists mentioned in this article are at the USDA-ARS Western Regional Research Center, 800 Buchanan St., Albany, CA 94710 (415) 559-5600. ✦

Stabilized rice bran is used in multigrain breads, granola cereals, and several health and natural foods. Photo courtesy of Riviana Foods, Inc.

Scientists Fight Brush With Imported Insects

Ranchers' biggest brush problems on the range are about to be pitted against imported enemies from South America and the Middle East.

Found from California to Texas, brush such as snakeweed and mesquite does have its uses, providing emergency grazing, wildlife habitat, and, in the case of mesquite and saltcedar, adornment for southwestern yards.

But it also competes with more desirable grasses for water and nutrients, according to C. Jackson DeLoach, Jr., a research entomologist with the Agricultural Research Service. DeLoach works at ARS' Grassland, Soil, and Water Research Laboratory at Temple, Texas.

Fighting the brush can be tough. It is not feasible to spend much per acre for chemical controls in an area "where it takes 20 to 50 acres per cow for grazing," says DeLoach. "So biological controls are a good way to go."

Biocontrols might be either an insect or a fungus, but they are hard to find for native plants because "there's nowhere else to look for natural enemies," DeLoach says.

He says, "We figure we have a chance working on these native plants because there are other species in the same weed genus occurring in South America. We hope to find insects there that evolved with the plant, and bring them up here."

Snakeweed, or *Gutierrezia, c*onsidered the most troublesome rangeland weed in New Mexico, covers about 143 million acres in the western United States. A dense perennial shrub that grows only about a foot tall, it also poses a serious problem in other southwestern states. It is found from southern Canada to central Mexico.

Snakeweed causes pregnant cows to abort but doesn't kill adult cattle. "They may eat enough to get sick but not to die," DeLoach says.

Cooperative efforts with Hugo Cordo at ARS' Biological Control Laboratory at Hurlingham, Argentina, near Buenos Aires, have turned up two insects that may break snakeweed's grip on the United States.

One, *Heilipodus ventralis,* is a weevil that bores into snakeweed's roots. Its introduction into the United States has already been approved by USDA's Animal and Plant Health Inspection Service (APHIS), and the first weevils were released last summer .

The second, a moth called *Carmenta haematica,* is also a root borer. It is still being tested in quarantine at the Temple lab. DeLoach hopes to get permission to release it in the United States within a year or two.

Another important brush target is mesquite, a knotty, thorny tree that can grow 30 feet tall and infests about 94 million acres of U.S. rangeland.

"There are insects that attack every part of mesquite and as near as we can tell, these insects don't eat other plants. It looks very promising."

C. Jackson DeLoach, Jr., Agricultural Research Service, Temple, Texas

"Mesquite has some beneficial value," DeLoach says. "It can be a very nice shade tree, and a lot of people have it in their yards. The pods are very palatable and cattle and horses love them. Also, it is an important wildlife habitat along streams in the arid Southwest.

"But it's a major weed. It uses water and competes with grass. And it's a problem to ranchers—cattle get in the thickets and they can't find them. The ranchers hate mesquite more than snakeweed."

DeLoach says the chances of finding a natural enemy of mesquite in South America are good.

"Mesquite originated in Argentina," he says. "They have 28 species; we have 9 in North America, but only 4 of these in the United States. None of the species are exactly the same as ours, but we think insects would adapt to our species, since they are closely related to some of theirs.

"The South American insects attack every part of the plant and as near as we can tell, these insects don't eat other plants. It looks very promising."

The biggest stumbling blocks to biological control of mesquite are the plant's popularity as an ornamental and its wildlife and other beneficial uses, DeLoach says, "but one possibility is something that just kills the seeds. People who have mesquite in their yards don't care about it reproducing, and there are 6 to 10 insects in Argentina that attack mesquite's seeds and pods."

Saltcedar, first introduced in the United States from the Middle East in 1837 as an ornamental, also poses a problem with its double identity as both pest and decoration. A bushy tree that forms dense thickets, saltcedar grows to heights of 30 feet. Its leaves secrete salt, which forms a layer on the ground that prevents other plants from growing. In large areas, it has crowded out all the native vegetation.

Saltcedar also has supporters among hunters, as it provides a habitat for the whitewing dove, and among beekeepers, since it is a "good honey plant."

"It grows along streams and western rivers from central Texas to California, up to Montana and down to Mexico," DeLoach says. "Only about a million acres are infested, but it's very choice land next to water."

DeLoach has been working for more than a year on a feasibility study of biological control of saltcedar, funded in part by a grant from the federal Bureau of Reclamation.

He has not yet obtained permission from APHIS to go ahead with biological control efforts against saltcedar, but he is optimistic.

"Biological control would take the saltcedar out gradually, giving the natural plants time to grow back and provide wildlife habitat," he says. "And the

Snakeweed may have finally met its match in *Heilipodus ventralis*, a tiny weevil imported from South America to battle the weed that now infests about 143 million acres of rangeland in the United States. (K-2990-1)

insects wouldn't take out all of the saltcedar. I expect there would still be enough for the beekeepers and the dove hunters."

DeLoach says research has turned up at least a dozen species of insects that might be used to fight the saltcedar.

Another factor favoring biological control is the dual nature of saltcedar.

"There are two species here—one that's weedy and one that's a beneficial evergreen," he says. "Bees feed on both and doves like both, but some insects in Israel and Pakistan attack only the weedy kind.

Another important brush problem is baccharis, a willowlike woody shrub that grows 15 to 20 feet tall and has an extensive root system. The United States has about two dozen native species of baccharis; three are considered undesirable. *Baccharis salicifolia*, commonly called seepwillow, is seen from Texas to California. *Baccharis halimifolia*, also known as saltwillow, grows from the Florida coast to Texas, and *Baccharis neglecta*, or pasturewillow, is found primarily in south-central Texas.

Like saltcedar, these species compete with grasses for any available water. In addition, "seepwillow forms large thickets across waterways, slowing down the flow and reducing water downstream," says Paul E. Boldt, an ARS entomologist at the Temple laboratory.

Since *baccharis* species in Argentina and Brazil are believed to be closely related to those in the United States, scientists are once again looking in South America for possible natural enemies.

"About 20 to 30 insects should be tested, but how many will work out, I don't know," Boldt says. "So far, we've tested two in quarantine here at Temple. It looks like we'll reject one, because it appears to do quite well on ornamental *baccharis*.

"But the other, a beetle called *Stolas fuscata*, looks very host specific. It feeds on the leaves of seepwillow and does a good job of defoliating the plant. We've tested it on 100 plants, and it doesn't bother any economically important plant, although it does feed on another weed."

An adult *Stolas fuscata* measures one-fourth to three-eighths of an inch long. Boldt began testing the insect in 1984 and finished his quarantine testing in January. The next step is to seek APHIS permission for release.

"We don't know how this insect will do in our hot Texas temperatures," he says. "But with biological controls, you have to be an optimist. You may have nine projects that fail, but if the 10th one is a success, it's usually beneficial enough to carry the cost of all the research."--By **Sandy Miller Hays**, ARS.

C. Jackson DeLoach Jr. and Paul E. Boldt are in USDA-ARS Grassland Protection Research, P.O. Box 748, Temple, TX 76503 (817) 770-6537 and (817) 770-6530. ✦

Polyester Repairman Is Really a Bee

An Agricultural Research Service scientist has identified a wild bee that carries its own repair kit for sealing polyester.

Entomologist Philip F. Torchio says adult females of the genus *Epeolus* do the repair job to protect their newly laid eggs.

Females of this parasitic bee cut slits in the polyester brood sacs constructed by the host bee, *Colletes*. The *Epeolus* female then inserts her egg through the slit and secretes an enzyme to patch the cuts.

About the size of a thimble, the host's polyester cell lining resembles a see-through sandwich bag and is waterproof.

"We don't know of any other insects that have this relationship," says Torchio. He is at the Bee Biology and Systematics Laboratory in Logan, Utah.

"Whether this type of polyester could be synthesized commercially is an intriguing question," he says. "But for now, it's one we aren't looking into."

The first report of the polyester-making bees came in 1979 from agency colleague Suzanne W.T. Batra, an entomologist at the Beltsville, Maryland, research center. She and Abraham Hefetz and Henry M. Fales, chemists at the National Institutes of Health, Bethesda, Maryland, discovered that *Colletes* bees fashion their brood sacs from polyester.

Torchio first observed the bees building nests and laying eggs in limestone cliffs at Bonny Doon, California, about 60 miles south of San Francisco. Neither species bothers humans.

The polyester process begins when the host bee, *Colletes,* secretes lactones—basic building blocks for the polyester—from a gland in its abdomen. To these, the bee may add catalysts from its salivary gland, which connect or polymerize the lactones into waterproof polyester chains.

Resembling the plastic in a see-through sandwich bag, polyester cell lining constructed by the *Collettes* bee provides waterproof protective environment for its eggs. Hole at upper right has been cut by a parasitic bee. (89BW0522)

Colletes deposits the nectar and pollen grains on which its newborn larva will feed after it hatches. Then she lays a single egg within each polyester sac. The full-grown larva remains sealed in its snug compartment until the following year when the adult cuts its way out of the polyester sac.

The unwelcome *Epeolus* enters the active host nests, cuts a slit in the wall of the polyester sac, and inserts her own egg through the slit. She then repairs the slit by secreting lactones that dissolve the polyester.

According to Torchio, salivary enzymes secreted by *Colletes* remain active after the sac is formed. As a result, those lactones secreted by *Epeolus* are quickly incorporated into the polyester sac.

"When *Epeolus* lactones are secreted," explains Torchio, "the polyester surface first dissolves and then resolidifies to form a continuous layer of waterproof polyester that seals the *Epeolus* egg to the host's polyester sac. After the *Epeolus* hatches from its egg, it uses its long, sickle-shaped mandibles to destroy any eggs or larvae it encounters. It then consumes the nectar and pollen provided by its host."—By **Howard Sherman,** ARS.

Philip F. Torchio is in USDA-ARS Bee Biology and Systematics Research, Logan, UT 84322 (801) 750-2520. Suzanne W.T. Batra is in the USDA-ARS Systematic Entomology Laboratory, Beltsville Agricultural Research Center, Beltsville, MD 20705 (301) 344-2384. ✦

Bitter Compounds in Citrus May Be Beneficial

There's an ironic, bittersweet twist in the ongoing struggle to get rid of bitterness-causing compounds of some winter oranges and grapefruit.

Researchers have now discovered that one of the troublesome compounds, nomilin, may help fight cancer.

Luke K.T. Lam of the University of Minnesota, working with ARS colleague Shin Hasegawa of ARS' Fruit and Vegetable Chemistry Laboratory, Pasadena, California, has demonstrated that nomilin helped prevent cancerous tumors from forming in stomachs of 28 percent of the laboratory mice that were fed a potent carcinogen.

Another bitterness chemical, limonin, also had some anticarcinogenic effect, but much less than nomilin, Lam says.

His work raises important new questions about the bitterness agents—blamed for annual losses of

$6 to $8 million to California navel orange growers alone. Will the compounds have the same anti-carcinogenic benefits in humans? If so, can science modify citrus' production of these compounds to take advantage of those benefits, without increasing juice bitterness?

Hasegawa, who has devoted more than a decade to solving the puzzle of how citrus forms the unwanted chemicals, and how that process might be blocked, points to an intriguing possibility.

The approach he suggests is linked to the recent discovery of derivatives from nomilin and limonin. He and colleagues Zareb Herman and Raymond D. Bennett have shown that nomilin and limonin can occur as less bitter derivatives. The scientists have named these new compounds glucosides, for the sugar molecule, glucose, that each derivative contains.

An average 6-ounce glass of orange juice contains "a very high concentration" of glucosides, Hasegawa says.

He proposes that if these newly found derivatives turn out to have the same cancer-fighting benefits as the parent chemicals, and if these benefits occur in humans—not just mice—why not try to boost citrus' natural conversion of the unwanted parent compounds to the helpful derivatives?

Such a strategy might be feasible, he says, through conventional plant breeding, genetic engineering, or use of some harmless outside agent that would stimulate the conversion. If studies show the derivatives have health benefits or improve the taste of citrus juice, the idea might be worth trying.—By **Marcia Wood,** ARS.

Shin Hasegawa, Zareb Herman, and Raymond D. Bennett are with USDA-ARS Fruit and Vegetable Chemistry Laboratory, 263 South Chester Ave., Pasadena, CA 91106 (818) 796-0239. Luke K.T. Lam is at the University of Minnesota, Gray Freshwater Biological Institute, Navarre, MN 55392 (612) 471-0013. ✦

Which Little Pig Is Fated To Be Fat?

ARS scientists have a new test that could help livestock breeders produce leaner pigs and other meat animals.

"Fat-conscious consumers are shifting toward less and leaner meat. From 1980 to 1987, per capita consumption of pork dropped about 13 percent. To stay competitive at the meat counter, the pork industry has to produce a pig with less fat," says ARS physiologist Gary J. Hausman.

Fat is a major contributor to health problems in the United States today. It has been implicated in adult-onset diabetes, heart attack, stroke and kidney problems, and a host of other maladies. ARS scientists are studying ways to reduce the amount of fat in pigs and other livestock.

"We are developing a test for obesity in very young animals," says Hausman, who is with the Animal Physiology Research unit in Athens, Georgia. "We can tell with a harmless blood test which young pigs will be fat and which will be lean."

The test would reveal to breeders and farmers which pigs in a litter will become lean adults. That could save time and money wasted in raising and breeding pigs that are fated to be fat.

Hausman describes the test. "We first have to grow rat adipose or fat cells in culture. Specifically, we need pre-adipocytes, that is, rat cells before they develop globules of oily fat in their cytoplasms."

To separate out the pre-fat cells, a sample of rat fat cells is placed in a digesting medium to dissolve the glue that binds the cells together. The cells are then centrifuged to bring down the pre-fat cells since the fat globules in the more mature fat cells make them float. The separated pre-fat cells are then cultured in a growth medium.

To run the test, about 10 milliliters of blood serum from the subject pig is placed in the growth medium of the pre-fat cell cultures. In 7 to 8 days, the cultures are tested for the enzyme glycerol phosphate dehydrogenase.

"We found that cultures given serum from pigs that were genetically destined to be fat when they matured had four times as much enzyme compared to serum from lean pigs of the same age," says Hausman.

"It's clear the test works." But he adds, "It won't be practical for production until we can skip the cell culture phase and test serum directly for the chemical that makes the rat pre-fat cells produce more glycerol phosphate dehydrogenase."

"In the future, a practical test for obesity may have a use in human medicine," Hausman says. "It would alert physicians and parents of the possibility of a child's becoming an obese adult. An early program of diet, exercise, and possibly medical treatment might prevent adult obesity."—By **Vince Mazzola,** ARS.

Gary J. Hausman is with the USDA-ARS Animal Physiology Research Unit, Room 305, Richard B. Russell Agricultural Research Center, P.O. Box 5677, College Station Rd., Athens, GA 30613 (404) 546-3224. ✦

Letters

*We invite letters from readers and, from time to time, will share them in this column.—**Ed.***

On Grasshoppers: An ARS reader in Bozeman, Montana, says that one of the 1966 Benchmarks in Biological Control [March 1989, page 13] regarding *Bacillus thuringiensis* against grasshoppers "was quite a surprise."

That benchmark was in error. It should have read that Bt would become the top-selling microbial pesticide for use against caterpillars.

U.S. Department of Agriculture
Agricultural Research Service
Rm. 318, B-005, BARC-West
Beltsville, MD 20705

Official Business
Penalty for Private Use—$300

To stop mailing ☐
To change your address ☐
Send mailing label on this magazine and your new address to above address.

Bulk Rate
Postage and Fees Paid
U.S. Department of Agriculture
Permit No. G-95

Superintendent of Documents Publication Order Form

Order Processing Code
*6526

Charge your order. It's easy! MasterCard VISA CHOICE

☐ **YES** Please send me 10 issues of **Agricultural Research** SN 701-006-00000-3

1. The total cost of my order is $11.00 (International customers please add an additional 25%.) All prices include regular domestic postage and handling and are good through 5/89. After this date, please call Order and Information Desk at 202-783-3238 to verify prices.

Please Type or Print

2. _____
(Company or personal name)

_____
(Additional address/attention line)

_____
(Street address)

_____
(City, State, ZIP Code)

(_____) _____
(Daytime phone including area code)

3. Please choose method of payment:

☐ Check payable to the Superintendent of Documents
☐ GPO Deposit Account ☐☐☐☐☐☐☐☐–☐
☐ VISA, CHOICE or MasterCard Account
☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

_____
(Credit card expiration date)

Thank you for your order!

_____
(Signature)

1/89

4. Mail To: Superintendent of Documents, Government Printing Office, Washington, D.C. 20402-9325